LED Luminaire Manufacturing Trends

DOE SSL Manufacturing R&D Workshop

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Cree, Inc.

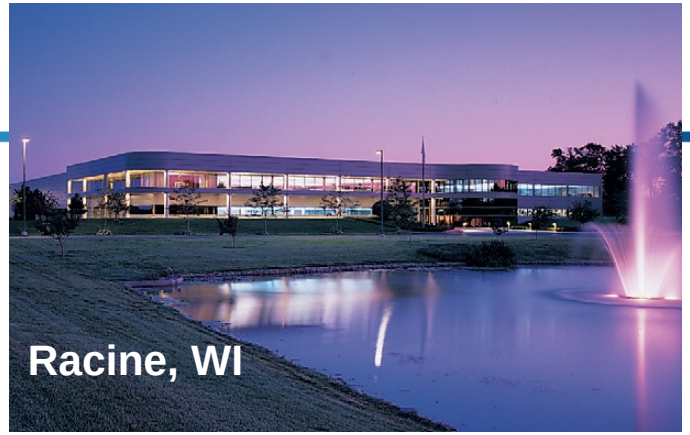
LED Luminaire Manufacturing Trends

How is manufacturing evolving to:

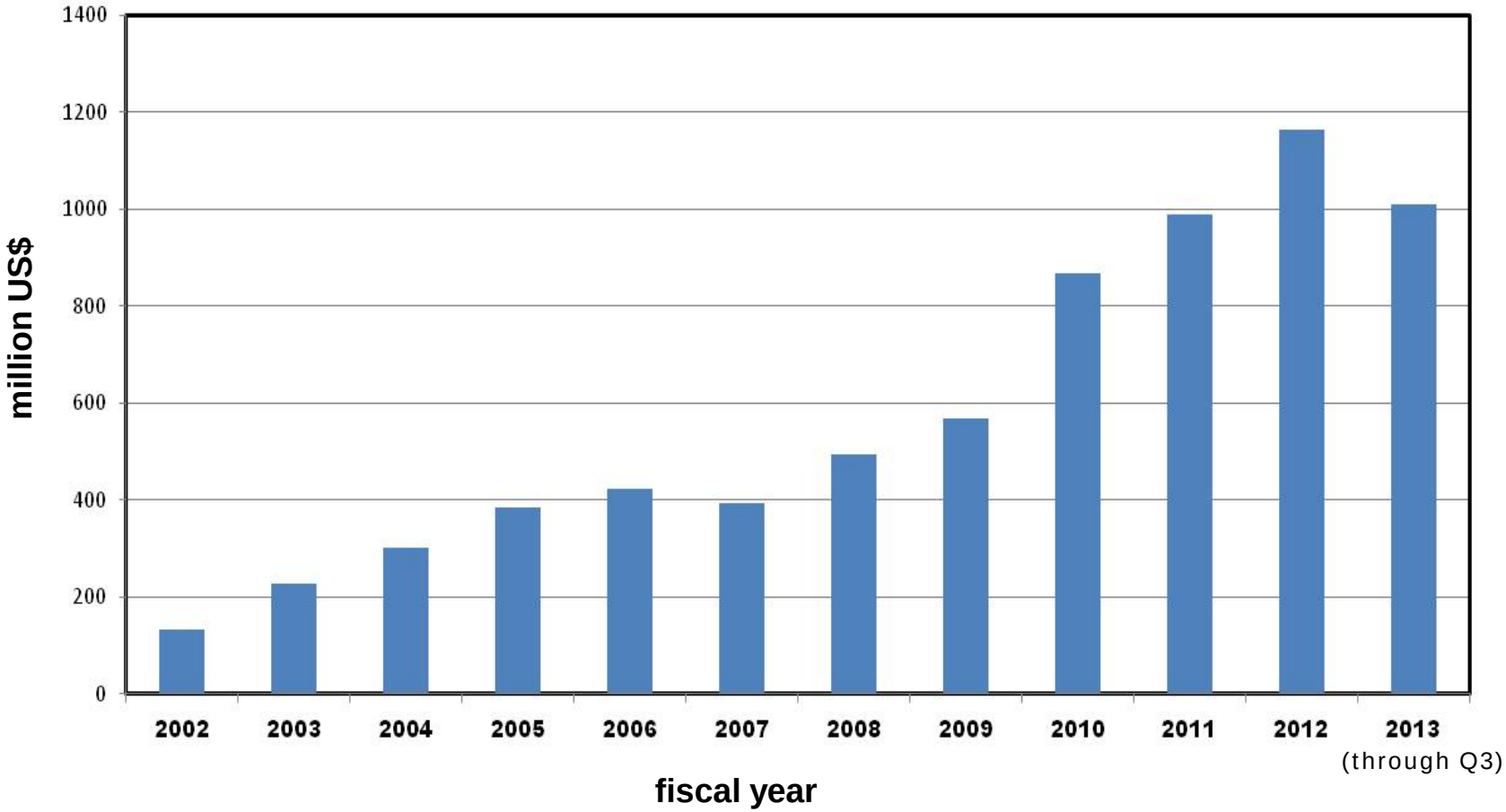
- **Maintain flexibility and short cycle times?**
- **Improve quality and consistency?**
- **Optimize reliability?**
- **Reduce costs?**
- **Keep manufacturing in the US?**

Cree - Vertically Integrated SSL Manufacturing

Manufacturing Locations



Yearly net income (through first 3 quarters FY'13)



This is a WORKSHOP

- **Exchange of Ideas**
- **Stimulate Thinking**
- **Promote Creativity**

KEYS TO MANUFACTURING SUCESS:

- **Innovation**
- **Design for Manufacturing**
  (“Good Manufacturing = Good Design”)
- **Automation**

Design for Manufacturing (DFM)

Basic Tenets:

- **Reduce total number of parts**
- **Develop modular design**
- **Use standard components**
- **Design parts to be multi-functional**
- **Design for ease of fabrication**
- **Minimize handling**

Innovation Drives Low Cost

2007

- 42 LEDs
- 650 lm
- 12W

Retail ~$150

2012

- 5 LEDs
- 650 lm
- 9.5W

$25 Retail

Modular Design Concept

Application Specific Modular Design Concept

Modular Design

Optimized (Custom) Design

Flexibility
Interchangeability
Low Cost
High Quality

Lower Cost
Higher (2X) Efficiency
Faster Payback
Highest Quality

Lifespan of LED products is much shorter than in the past

Common Modular Design – Light Engine

An Integrated Solid-State LED Luminaire for General Lighting

February 3, 2009

Kevin Dowling, Color Kinetics

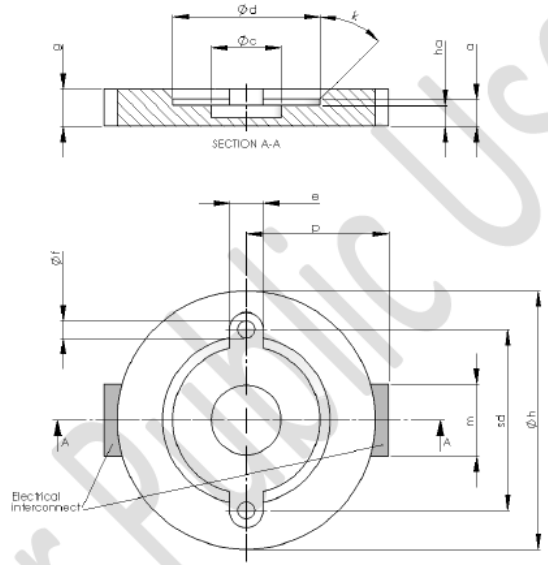


Figure 3: Drawing of mechanical dimensions of the LED Module

Zhaga

Common Module Designs

Benefits:

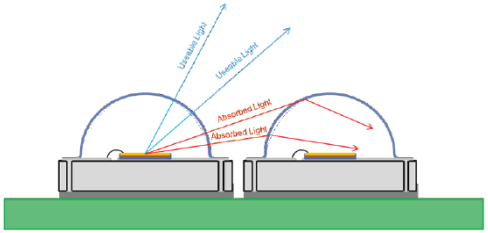
Allows those with limited LED technology experience to use

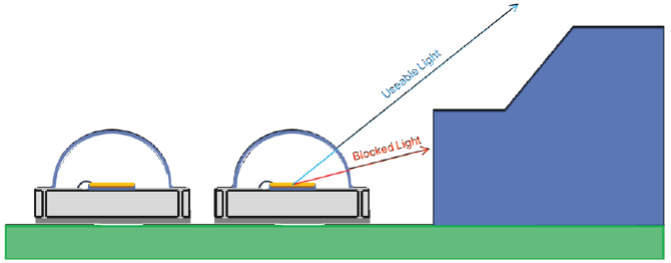
Multiple procurement sources

Lifespan of LED products is much shorter than in the past

Drawbacks:

Expensive
Inefficient
“Dumb’s Down” Technology
Based on old technology





A19 Construction Analysis

"One way that an electronics company saves money in manufacturing consumer products is by using as few parts as possible, and using those parts in as many other products as possible."

"Cree has used this tactic to design its recently-introduced family of incandescent-replacement LED bulbs, available in two versions: 450 lumens at 6W (40W-equivalent) for $10 and 800 lumens at 9.5W (60W-equivalent) for $13."

A19 Construction Analysis

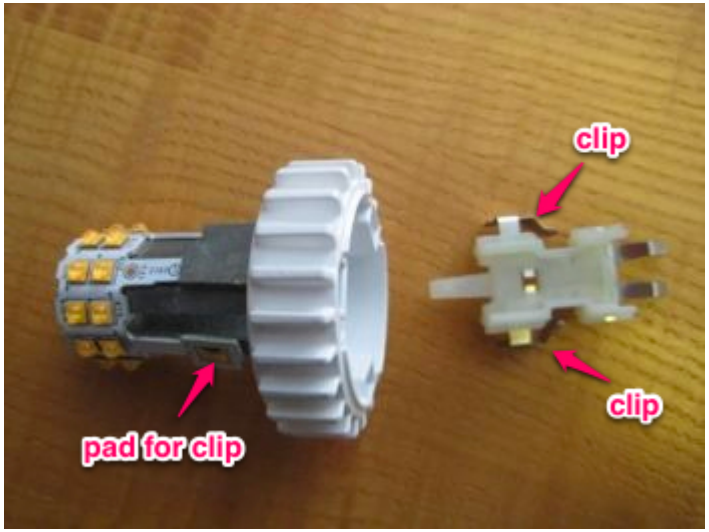
There are a total of 20 LEDs mounted in ten groups of two on a metal core pc board that's scored between each two LEDs and then bent into a ten-sided shape that slips over the column.

In addition, rather than relying on kludge-y hand-soldered connections, the bulb uses a couple of clips to transfer the power from the center of the LED column to the LED array on the outside of the column.

The whole assembly almost snaps together, making it easily and reliably assembled.

Manual Hand Solder or…

vs.



Maintain flexibility and short cycle times?
Improve quality and consistency?
Optimize reliability?

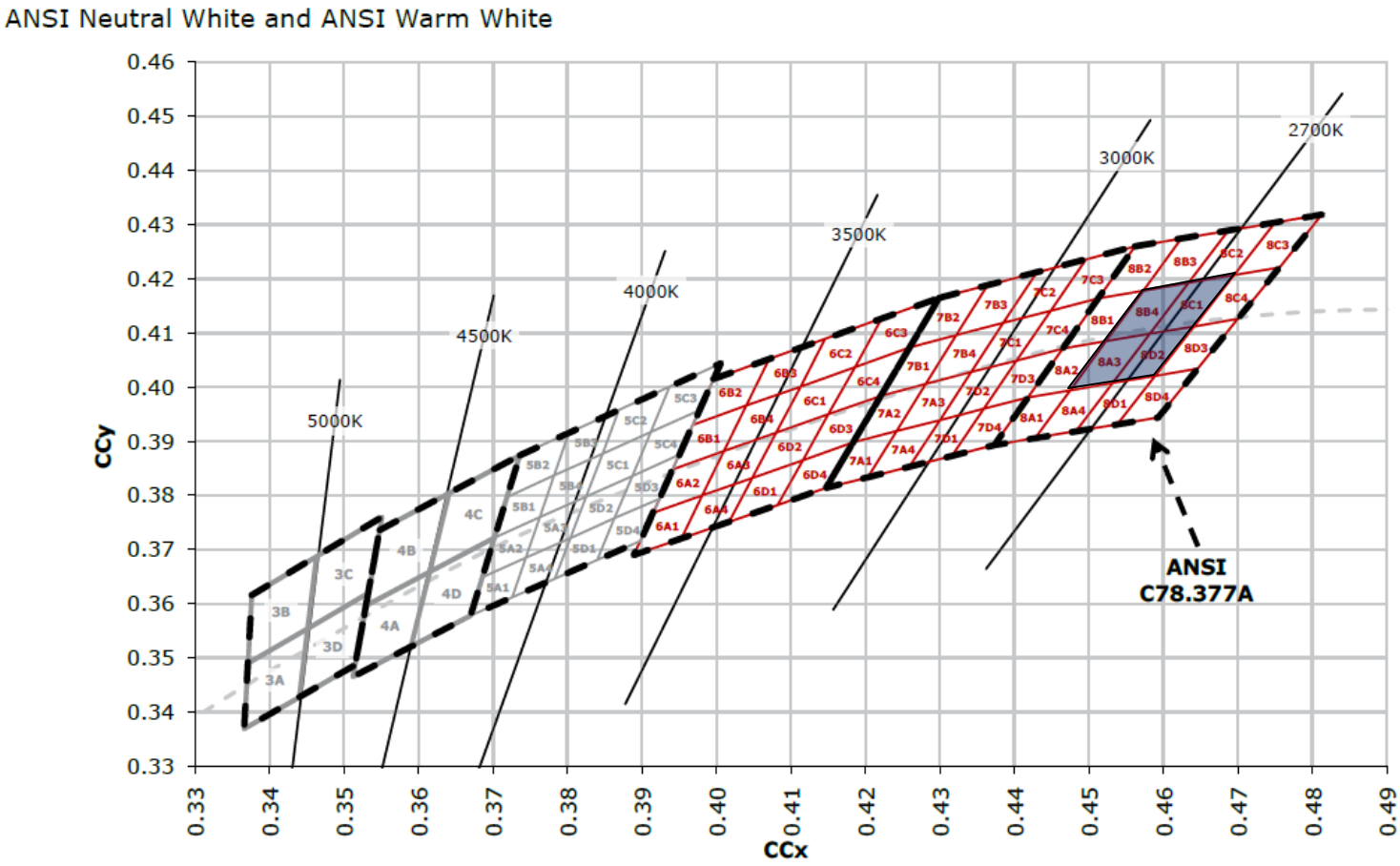
You bet it does!

A19 Construction Analysis

"It's clear that almost 90% of the cost factors are in the LEDs, the heat sink, the LED driver and associated components, and the EMI filter. Furthermore, they are very close to each other in costs."

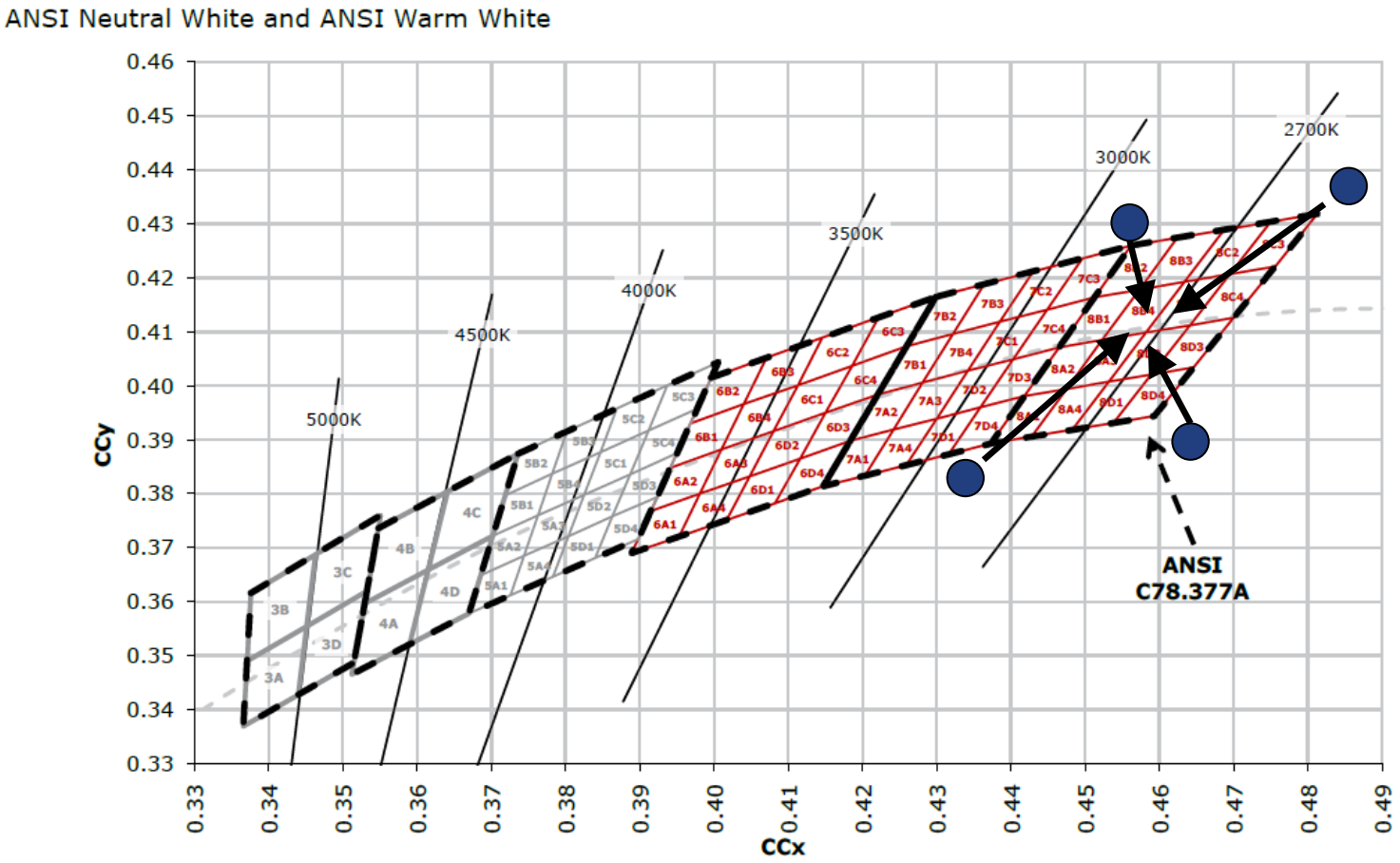
"So, the take-away here is that there is no one single cost factor driving the total cost of a bulb. To bring the total cost down, incremental reductions across all these items must be made."

Reduce Cost through Component Selection



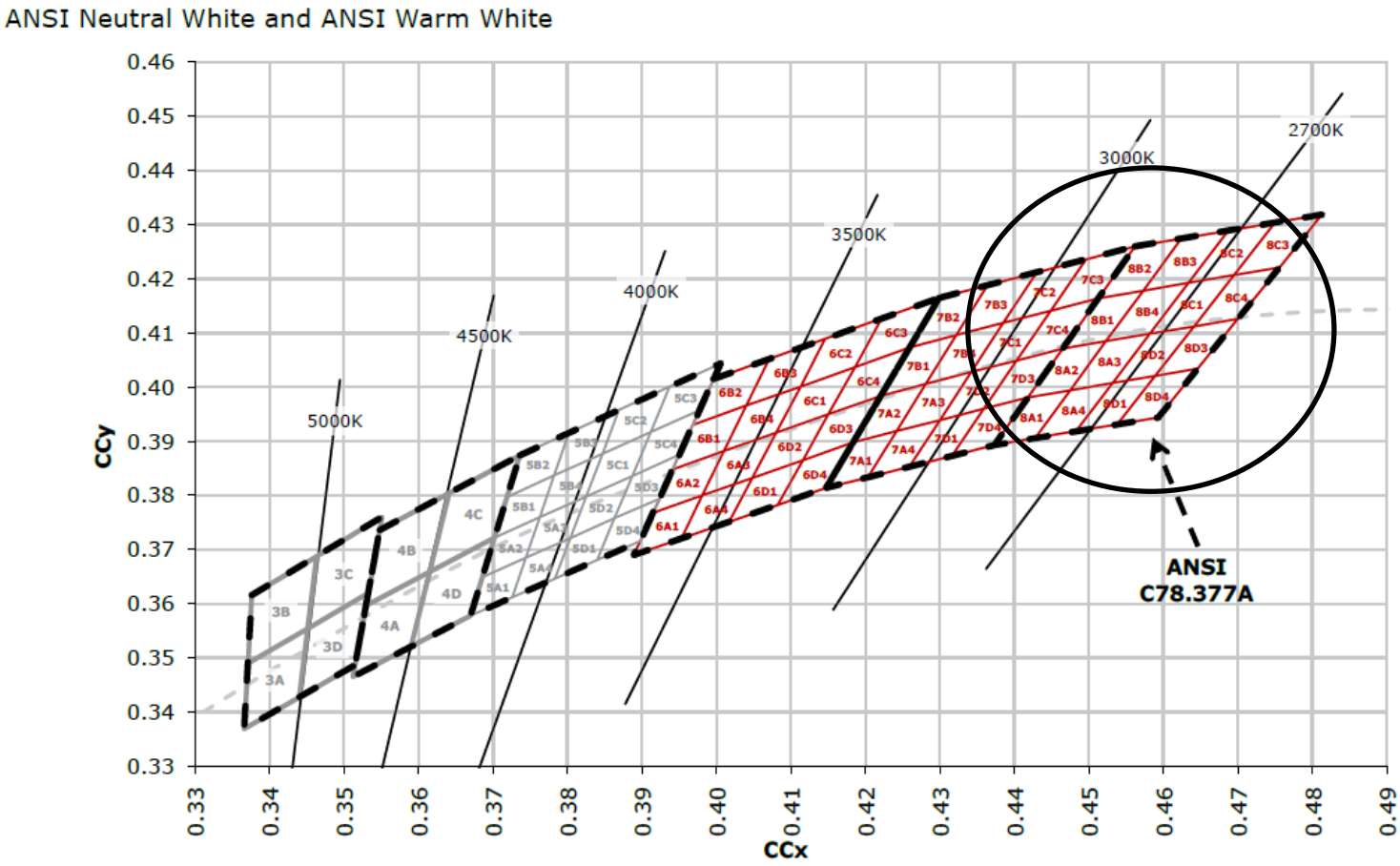
Limiting LED package requirements is expensive!

Component Selection



Mix different LEDs to achieve final color consistency

Component Selection



Using a <u>wide distribution</u> of available LEDs is always less expensive!

Reduce Cost through Component Selection

Many imperfections do not effect product reliability or light quality.

DIGITIMES

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Taipei, Tuesday, M[illegible]2013 19:27 (GMT+8)

Revenues for drivers in LED general lighting applications to triple, says IMS Research

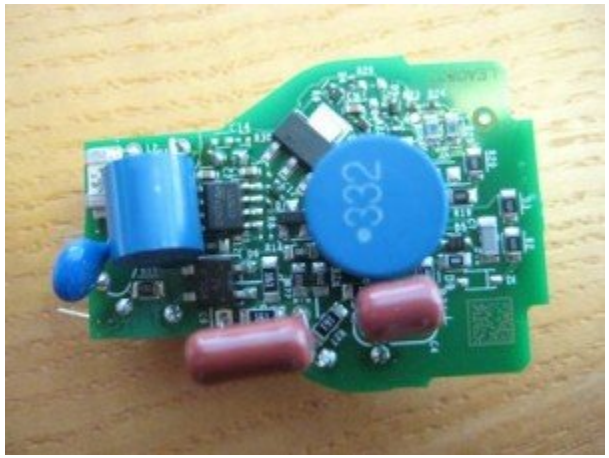
[illegible]: Jessie Shen, DIGITIMES [Tuesday 21 May 2013]

Global revenues for LED driver [illegible] applications will more than triple from 2012 to 2015, as the market for solid-state illumination booms, according to IMS Research.

> The market governing LED driver ICs for lighting will surge to US$666 million in 2015, up from US$214 million in 2012, said IMS. Growth will moderate somewhat during the following years, but revenues are expected to continue to expand, reaching US$810 million in 2018.

"Major advances and cost reductions in lamps, luminaires and automotive lighting are spurring the rapid growth of the market for LEDs in general lighting applications," said Stephanie Pruitt, lighting and LEDs analyst for IMS. "This in turn is generating major opportunities for LED driver ICs. Once dominated by the display backlighting business, the LED driver IC market now is being driven by the soaring market for general lighting."

Custom Design Driver



vs

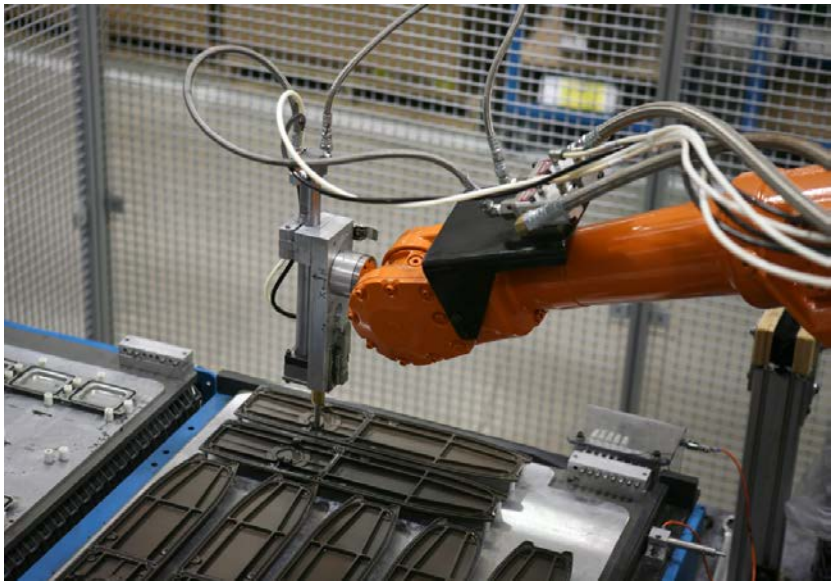
Off the Shelf Driver

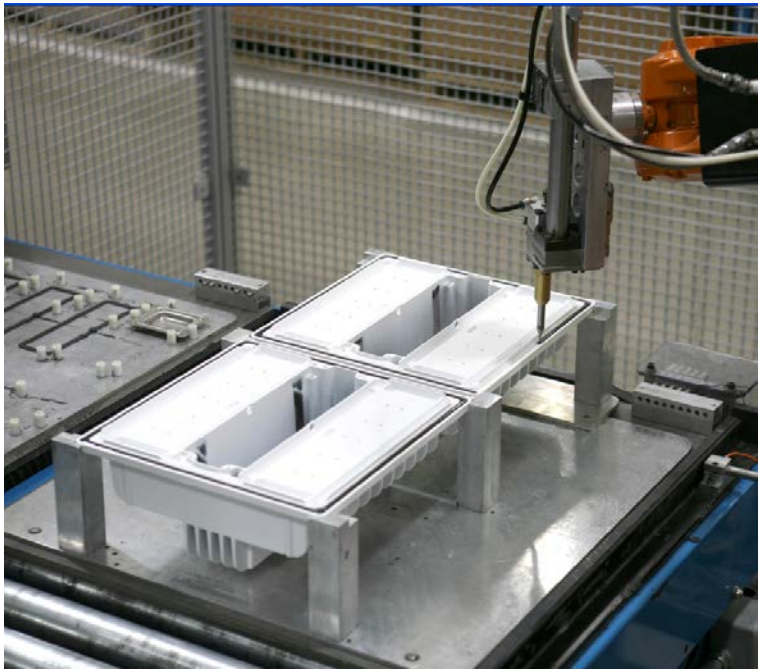
Less Expensive
Flexibility
Quality & Reliability?
Requires technical expertise

More Expensive
Less Flexible
Good Quality & Reliability
Limited expertise needed

Traditional Assembly Line or…

…Automation?





Maintain flexibility and short cycle times?
Improve quality and consistency?
Optimize reliability?
Reduce costs?

AVI (Automated Visual Inspection) preferred

More than one-third of executives at big manufacturing firms say they're either considering moving production into the U.S. from China, or that they're already planning to do it, according to a recent poll from the Boston Consulting Group.

"This comes even as top executives, including the heads of General Electric Co and Boeing Co, admit that they went too far in moving operations out of the United States."

NOLOGY | Updated May 29, 2013, 9:28 p.m. ET

Motorola to Make New 'Moto X' Smartphone in U.S.

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Apple's next Macs will be made in the USA

The Washington Post

Is U.S. manufacturing making a comeback — or is it just hype?

By Brad Plumer, Updated: May 1, 2013

- Flexibility to address markets outside of China
- Low energy costs
- Wages in China continue to increase
- Freight costs continue to increase
- Productivity of US workers continues to increase

- Innovation in the US
- Automation offsets labor costs

In Summary:

How is manufacturing evolving to:

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- Improve quality and consistency?
- Optimize reliability?
- Reduce costs?
- Keep manufacturing in the US?

- Innovation
- Design for Manufacturing
- Automation

Thank You!

And Thanks to Jim Broderick and the DOE!